UDC 635.658:631.527 https://doi.org/10.21498/2518-1017.19.2.2023.282548

Characteristics of introduced lentil varieties (*Lens culinaris* Medik.) in the Southern Forest Steppe zone of Ukraine

S. M. Kholod[1*], N. V. Kuzmyshyna[2], O. V. Tryhub[1], V. M. Kirian[1]

*[1]Ustymivka Experimental Station of Plant Production of Plant Production Institute nd. a. V. Ya. Yuriev of NAAS of Ukraine, 15 Akademika Vavylova St., Ustymivka, Hlobyno district, Poltava region, 39074, Ukraine, *e-mail: svitlanakholod77@ukr.net*
[2]Plant Production Institute nd. a. V. Ya. Yuriev of NAAS, National Center for Plant Genetic Resources of Ukraine, 142 Heroiv Kharkova Ave, Kharkiv, 61060, Ukraine, e-mail: ncpgru@gmail.com

Purpose. To evaluate the introduced lentil varieties (*Lens culinaris* Medik.) originating from Canada and Spain in the conditions of the Southern part of the Forest-Steppe of Ukraine according to a complex of indicators of productivity and adaptability. **Methods.** During 2019–2021, in the conditions of the plant research station Ustymivka Experimental Station of Plant Production of the Plant Production Institute of the NAAS of Ukraine (Poltava Region, 49°18′21″N, 33°13′56″E), 26 new samples of lentils from Canada and Spain were studied. In the pod and seed ripening stage (BBCH 86–90), under field and laboratory conditions, indicators of yield, productivity, 1000 seed weight, early-ripening, plant height and height from the soil of the first pod, number of pods and seeds per plant, number of seeds in a pod, pod parameters. **Results.** In the process of studying the new lentil samples, it was found that their productivity varied from 127 to 258 g/m^2, with the most productive varieties being 'CDC Creenstar', 'CDC Cherie' (Canada), 'Angela', 'Amaya' (Spain). Throughout the study period, the highest productivity, according to the indicator "seed weight per plant", was shown by the plants of the following lentil varieties: 'CDC Cherie' (4.4 g), 'CDC Creenstar' (4.2 g), 'CDC Greenland' (4.5 g), 'CDC Imigreen' (4.4 g), 'CDC QG-2' (4.1 g), 'CDC Impulse' (4.0 g) (Canada), 'Angela' (4.6 g) (Spain). Plant productivity was high, both in terms of increased number of seeds and 1000 seed weight. The highest level of the indicator of the number of pods per plant was recorded in the lentil varieties 'CDC Imax' (64.4 pcs), 'CDC Impala' (65.5 pcs), 'CDC QG-2' (67.4 pcs), 'CDC Creenstar' (67.8 pcs), 'CDC Cherie' (75.2 pcs) (Canada), 'Amaya' (64.8 pcs), 'Angela' (75.1 pcs) (Spain). Almost all the examined samples were of medium ripeness (81–85 days) and optimal for the Southern Forest Steppe Zone of Ukraine. The Canadian varieties 'CDC QG-2', 'CDC SB-2', 'CDC Impulse', 'CDC Imvincible', 'CDC Impact' were the earliest (76 days). Varieties combining several valuable characteristics deserve special attention: 'CDC Creenstar', 'CDC Greenland', 'CDC Impulse', 'CDC Impact' (Canada), 'Angela' (Spain). **Conclusions.** The above mentioned varieties can be recommended as sources of valuable traits for practical use in breeding, and they are also suitable for cultivation in the Southern Forest Steppe Zone of Ukraine.

Keywords: *valuable economic characters; productivity; growing season; plant height; 1000 seed weight.*

Introduction

Lentil (*Lens culinaris* Medik.) is an important legume crop grown for food and fodder and is one of the oldest crops cultivated by humans [1, 2], which is currently not widespread in Ukraine [3]. Lentils are grown in over 52 countries. The main lentil producing countries are Canada, India, USA, Turkey, Australia, Kazakhstan, Nepal, Russian Federation, Bangladesh, China and Ethiopia, which account for more than 93% of world production. Today, lentils are grown on an area of 6.1 million hectares worldwide, with an annual production of 6.3 million tonnes and a yield of 1,038 kg/ha [4, 5]. In Ukraine, the average yield of lentils is between 10–12 t/ha and is grown in forest-steppe and steppe zones [6].

According to the literature, lentil seeds contain between 20 and 36% protein, depending on the variety [5, 7]. It is a source of B vita-

Svitlana Kholod
http://orcid.org/0000-0002-2443-0879
Nataliia Kuzmyshyna
http://orcid.org/0000-0001-8046-1760
Viktor Kirian
http://orcid.org/0000-0001-8730-8507
Oleg Tryhub
http://orcid.org/0000-0003-3346-9828

mins (thiamin, riboflavin, niacin), β-carotene, essential minerals (such as sodium, potassium, calcium, magnesium, phosphorus, iron), has a high content of essential amino acids [8, 9], is rich in complex carbohydrates, is an important source of energy [10, 11], and has therapeutic value [12, 13]. Among the leguminous crops, lentils is an important food crop in terms of global production, trade and popularity among final consumers [14], so it is widely used in diets and daily nutrition [15, 16]. Like all other leguminous crops, it contributes to the accumulation of nitrogen in the soil, improving its fertility and structural properties. In addition, lentils clear land early and use moisture sparingly, making it a good precursor for winter crops [17, 18].

However, the issue of lentil genetics and breeding is still not given enough attention in our country, which undoubtedly hinders the development of effective breeding methods for this valuable food crop and its diffusion in production. In order to increase the productive potential of lentils, it is important to study its gene pool, taking into account the main elements of productivity (biological and morphological). At the same time, the most important work is the search for new sources, the creation and selection of breeding material adapted to the conditions of a specific region, taking into account the variability of the environment and its limiting factors.

The aim of the research is to evaluate the newly introduced lentil varieties of Canadian and Spanish breeding in the conditions of the southern part of the Ukrainian Forest-Steppe according to a set of indicators of productivity and adaptability.

Materials and methods

The field and laboratory research was conducted in the introductory quarantine nursery of the Ustymivka Experimental Station of Plant Production of the Plant Production Institute named after V. Ya. Yuriev of the National Academy of Agrarian Sciences of Ukraine (hereinafter – UESPP) during 2019–2021 (Ustymivka village, Kremenchuk district, Poltava region. Location 49°18′21″N, 33°13′56″E, 94 m above sea level). In the area where the UESPP is located, the climate is moderately continental with unstable humidity, cold winters, hot and often dry summers. The average annual temperature is +8.2 °C, with a maximum of +38 °C (July) and a minimum of −26 °C (January). It should be noted that the average annual temperature in the region has increased by more than 1 °C in the last 10 years. Annual rainfall ranges from 430 to 480 mm. The soils are medium-loamy heavy chernozems with a humus content of up to 3.84%.

The following lentil varieties from Canada were tested ‘CDC KR-1’, ‘CDC Marble’, ‘CDC Asterix’, ‘CDC KR-2’, ‘CDC Peridot’, ‘CDC Cherie’, ‘CDC Dazil’, ‘CDC Creenstar’, ‘CDC QG-2’, ‘CDC SB-2’, ‘CDC Impulse’, ‘CDC Imvincible’, ‘CDC Maxim’, ‘CDC Proclaim’, ‘CDC Greenland’, ‘CDC Impact’, ‘CDC Impala’, ‘CDC Imax’, ‘CDC Imigreen’, ‘CDC Impower’; from Spain ‘Alcor’, ‘Angela’, ‘Amaya’, ‘Pardina’, ‘Lenteja Lura’, ‘Lenteja Aplo’. The examined material is a part of the samples received by the National Centre for Plant Genetic Resources of Ukraine within the framework of the ecological study of foreign material based on a complex of economically valuable characteristics in different zones.

Field trials were carried out on a bare fallow with generally accepted agricultural machinery. The design of the trials, the evaluation and analysis of the data obtained in terms of yield and quality indicators were carried out in accordance with the methodological recommendations for the study of genetic resources of leguminous crops [19]. The sowing was carried out manually in two repetitions during the optimum period for lentils (I–II decade of April). The three-row plots are 4 m long with 0.20 m between rows, with an area of 2.4 m^2. The sowing rate is 100 seeds per 1 m^2. The standard variety used is ‘Linza’, a lentil of Ukrainian origin, sown in 20 numbers. Manual weeding was crop care.

Observations and descriptions of the variety samples were made during the growing season. During the growing season, the following phenological stages of lentil development were recorded: seedling (BBCH 09), beginning of flowering (BBCH 60), full flowering (BBCH 65), development of fruit (BBCH 71), full maturity (BBCH 89). At mass flowering, the colour of the flowers was recorded and disease damage to the plant was scored on a 9-point scale. At full maturity stage (BBCH 97) in the field, plant height and the height of the lowest bean pod above the ground were measured. Harvesting was done by hand. After structural analysis, the sheaves were threshed. Under laboratory conditions, a structural analysis was carried out according to the following quantitative characteristics: number of pods per plant, number of seeds per plant and seeds per pod, taking into account the Methodology for the Examination of Plant Varieties of the Leguminous and Cereal Groups for Distinctness, Uniformity and Stability [20] and the

Manual on Identification Signs of Leguminous Crops (Beans, Chickpeas, Lentils) [21]. The statistical analysis of the obtained results was carried out using descriptive statistics. A standard software package (Microsoft Excel) was used to statistically process the research results and to determine the reliability of the obtained experimental data.

The meteorological conditions of the growing season during the period of material research made it possible to analyse the introduced variety samples for their adaptability to the conditions of the Southern Forest Steppe and to evaluate them according to economically valuable characteristics.

The spring-summer (April-July) lentil growing season in 2019–2021 was characterised by contrasting hydrothermal indicators, particularly the amount and distribution of precipitation during the lentil growing season (Table 1). The average daily temperature during the lentil vegetation period was 19.2 °C (2019), 18.4 °C (2020), 18.3 °C (2021), the long-term indicator was 16.3 °C, the amount of precipitation was 278.3 mm; 152.2 and 231.1 mm, respectively. The weather conditions in 2019 during the growing season were the most favourable for the growth and development of lentil plants. In all three years of the study, there was sufficient moisture in the soil during the seedling-flowering period to obtain full-grown seedlings and plant development. During the sowing-germination period of 2019–2021, the average daily temperature was at the level of 9.9 °C. The amount of precipitation in 2019 was 28.6 mm, in 2020 – 3.3 mm, in 2021 – 17.4 mm. In the seedling-flowering phase, the average daily temperature in 2019 was 17.5 °C, in 2020 – 14.3, in 2021 – 19.9 °C for the norm of 15.9 °C, the amount of precipitation – 133.3 mm; 107.2 and 113.4 mm, respectively. This allowed the lentil plants to produce a good vegetative mass and a fully developed ovary. During the period of seeds ripening the average temperature in 2019 was – 23,5 °C, in 2020 – 24,8 °C, in 2021 – 22,6 °C. The amount of precipitation in 2019 was 68.3 mm, in 2020 – 43.1 mm, in 2021 – 105.8 mm (according to the UESPP weather station).

Table 1

Hydrothermal regime during the years of lentil research (2019–2021)

Month	Decade	Average daily air temperature, °C				Amount of precipitation, mm			
		X	2019	2020	2021	X	2019	2020	2021
April	I	8.9	11.2	9.4	7.7	44	0.0	0.0	9.6
	II		8.9	10.1	10.0		26.0	3.3	5.0
	III		14.7	12.8	9.7		2.6	8.6	12.4
May	I	15.9	14.1	15.8	14.3	50	49.6	15.3	15.4
	II		20.2	14.8	17.3		7.6	13.1	14.6
	III		21.1	13.7	18.6		73.5	52.8	34.3
June	I	19.5	23.8	19.5	16.5	57	61.6	17.4	36.7
	II		25.9	26.6	22.1		0.0	4.2	64.3
	III		24.0	25.5	25.8		1.1	6.1	0.0
July	I	21.0	22.5	25.9	25.9	72	5.6	15.4	4.8
	II		20.9	21.6	26.5		4.3	16.0	16.8
	III		23.5	24.5	25.3		46.4	0.0	17.2
During the period		–	19.2	18.4	18.3	–	278.3	152.2	231.1

Note: X – a multi-year average.

Results and discussion

As a result of the study, the approbation and morphological characteristics of each lentil variety were established (Table 2). The evaluation was carried out under field and laboratory conditions for 25 plants.

Lentil is a cold-resistant crop, so it is sown in early spring when the soil has warmed up to 5 °C. In 2019, sowing took place on April, 8, in 2020 on April, 2, in 2021 on April, 14. In all years, all the lentil varieties had good seedlings. In 2019 the seedlings appeared on April, 18, in 2020 on April, 14, in 2021 – April, 24. The time of flowering was determined when 25% of the lentil plants had at least one flower. Flowering started in the first ten days of June, almost simultaneously in all varieties, except Spanish, which started 3–4 days later. In 2020, due to the dry and warm weather, ripening was earlier – in the first ten days of July. In 2019 and 2021 it was in the second half of July. The length of the growing season is an important biological characteristic of plants and depends on temperature conditions – the higher the average daily air temperature, the shorter the growing season and, conversely, the lower the temperature, the

Table 2

Evaluation of introduced lentil varieties by morphological and economic characteristics (average for 2019–2021)

Variety sample	Country of origin	Length of vegetation period, days	Height, cm		Seed	
			plants	attachment of the lowest bean pod	coloring	form
'Linza', standard	Ukraine	90	42.8	24.4	light green	convex
'CDC KR-1'	Canada	89	32.8	19.6	gray	convex
'CDC Marble'	Canada	89	35.5	13.8	green	convex
'CDC Asterix'	Canada	78	30.0	13.5	green	flattened
'CDC KR-2'	Canada	89	36.5	15.2	gray	convex
'CDC Peridot'	Canada	78	36.5	11.5	green	flattened
'CDC Cherie'	Canada	78	39.9	20.8	gray	convex
'CDC Dazil'	Canada	79	37.5	18.5	gray	convex
'CDC Creenstar'	Canada	79	40.7	24.5	green	convex
'CDC QG-2'	Canada	76	40.4	16.0	green	convex
'CDC SB-2'	Canada	76	36.5	18.4	green	convex
'CDC Impulse'	Canada	76	42.5	23.4	gray	convex
'CDC Imvincible'	Canada	76	36.2	20.5	yellow	convex
'CDC Maxim'	Canada	80	34.5	22.2	gray	convex
'CDC Proclaim'	Canada	78	38.3	21.1	gray	convex
'CDC Greenland'	Canada	81	41.2	15.2	green	convex
'CDC Impact'	Canada	76	41.2	16.4	gray	convex
'CDC Impala'	Canada	82	33.8	19.4	gray	convex
'CDC Imax'	Canada	83	31.6	16.8	red	flattened
'CDC Imigreen'	Canada	83	39.2	16.4	green	flattened
'CDC Impower'	Canada	85	43.4	20.4	green	convex
'Alcor'	Spain	81	34.0	19.8	green	convex
'Angela'	Spain	84	44.8	23.8	gray-red	convex
'Amaya'	Spain	81	42.2	20.8	gray-red	convex
'Pardina'	Spain	81	35.0	10.7	brown	convex
'Lenteja Lura'	Spain	85	34.4	16.6	green	convex
'Lenteja Aplo'	Spain	85	32.0	20.8	pink	convex
X		81.1	37.3	18.3		
min		76	30.0	10.7		
max		89	44.8	24.5		
R (max–min)		13	14.8	13.8		
V, %		5.1	10.6	20.0		

Note: X, min, max, x – the average, minimum and maximum value, respectively; R (max–min) – range of variation; V – the coefficient of variation.

longer the growing season [22]. The length of the growing season and the duration of each phenological phase are very important in the selection of pairs for crossing and in the process of working with hybrid and breeding material, because early ripening varieties ensure timely harvesting, obtaining fully developed high-quality seed material [23]. The duration of the growing season for the studied lentil varieties ranged from 76 to 89 days (Table 2). Almost all the studied samples were of medium maturity (81–85 days), which is optimal for the Southern Forest Steppe zone of Ukraine. The earliest maturing varieties (76 days) were the Canadian varieties 'CDC QG-2', 'CDCSB-2', 'CDC Impulse', 'CDC Imvincible', 'CDC Impact'. Flowering of the lentils started on average 37–42 days after the emergence of the culture over the years of research. The most important period, responsible for the number of flowers on a plant, the duration of their formation, the conditions for filling and formation of the lentil crop is the "flowering-full ripening". Hydrothermal conditions have a significant effect on the duration of this period. Thus, low temperatures or high rainfall can delay ripening and extend the vegetation period by 2–3 weeks. In the structure of the vegetation period, lentil varieties have an average of 12 days for the sowing-germination period, 42 days for the seeding-flowering period and 31 days for the flowering-ripening period. The lentil varieties were studied according to the height of the main stem and the height of the attachment of the lowest bean pods above the soil level. It was found that the productivity of lentil plants depends largely on their height. This is explained by the fact that the longer the plant (shoot), the more fertile nodes, pods and seeds are produced. A lentil variety is considered to be highly technological if the plant height is at least 40 cm [24]. Table 2 shows that lentil varieties differ in plant height, which on average ranged from 30.0 cm (‘CDC Asterix’, Canada) to 44.8 cm (‘Angela’, Spain). At the physiological maturity stage of lentils, the tallest plants were found to be 40.0 cm in the varieties ‘CDC Creenstar’, ‘CDC QG-2’, ‘CDC QG-2’, ‘CDC Impulse’, ‘CDC Greenland’, ‘CDC Impact’, ‘CDC Impower’ (Canada), ‘Angela’, ‘Amaya’ (Spain). The coefficient of variation for plant height was 10.6%, range of variation – 14.8 cm.

The height of the attachment of the lowest bean pods and the length of the stem are among the characteristics that characterise the producibility of the variety. A high attachment of the lower pods makes it possible to reduce the loss of the lower tier seeds during mechanised harvesting. Especially valuable in this regard are varieties that have a high attachment of the lower pods (more than 15 cm) [24]. The average height of the lower bean pods in the years studied ranged from 10.7 cm (‘Pardina’, Spain) to 24.5 cm (‘CDC Creenstar’, Canada), average variability of the sign was observed (coefficient of variation – 20.0%). Among the introduced studied samples, 50% had a high attachment of the lower pod above the soil level (15–20 cm); the average is 11.0–14.0 cm in the ‘CDC Marble’ varieties, ‘CDC Asterix’, ‘CDC Peridot’ (Canada), ‘Pardina’ (Spain). In 9 samples (34.6%) very high pod attachment (more than 20.0 cm) were found: ‘CDC Cherie’, ‘CDC Creenstar’, ‘CDC Impulse’, ‘CDC Invincible’, ‘CDC Maxim’, ‘CDC Proclaim’ (Canada), ‘Angela’, ‘Amaya’, ‘Lenteja Aplo’ (Spain).

The main components of seed productivity include the following characteristics: the number of pods per plant and seeds per plant, the number of seeds in a pod, indicators of bean parameters, the weight of seeds from a plant and 1000 seed weight (Table 3).

The number of pods per plant is a characteristic largely influenced by environmental

Table 3

Evaluation of lentil samples by elements of the productivity structure (average for 2019–2021)

Variety sample	Yield, g/m^2	Number of beans per plant, pcs	Number of seeds, pcs		Pod dimensions, mm		Weight of seeds per plant, g	Weight of 1000 seeds, g
			from a plant	in a pod	length	width		
‘Linza’, standard	222	38.8	52.5	2.0	17	10	3.45	70.1
‘CDC KR-1’	210	60.2	92.2	2.0	15	8	3.29	39.3
‘CDC Marble’	201	55.8	78.3	2.0	13	9	2.52	32.2
‘CDC Asterix’	210	45.9	59.1	2.0	12	5	3.87	25.5
‘CDC KR-2’	160	36.0	44.2	2.0	12	5	2.04	32.1
‘CDC Peridot’	174	41.0	58.2	1.5	15	6	2.21	41.0
‘CDC Cherie’	248	75.2	123.1	2.0	14	7	4.40	38.1
‘CDC Dazil’	181	42.2	62.2	1.9	11	7	2.93	40.5
‘CDC Creenstar’	250	67.8	95.1	1.6	20	11	4.65	64.1
‘CDC QG-2’	202	67.4	94.2	2.0	13	8	4.08	32.9
‘CDC SB-2’	206	49.6	65.3	2.0	13	7	3.38	35.2
‘CDC Impulse’	194	51.6	72.6	1.6	15	9	4.50	45.2
‘CDC Imvincible’	163	52.4	84.3	1.8	14	7	2.41	31.1
‘CDC Maxim’	195	48.5	65.5	1.7	13	8	2.98	39.9
‘CDC Proclaim’	198	47.3	55.3	1.8	15	7	3.74	40.3
‘CDC Greenland’	228	62.2	91.1	2.0	11	5	4.50	31.7
‘CDC Impact’	216	63.0	92.0	2.0	14	6	3.31	55.0
‘CDC Impala’	208	65.5	93.1	2.0	15	6	3.75	40.0
‘CDC Imax’	166	64.4	92.2	2.0	14	6	3.41	37.6
‘CDC Imigreen’	187	63.0	91.5	1.6	15	9	4.37	50.5
‘CDC Impower’	194	48.8	63.2	1.8	14	6	2.24	55.0
‘Alcor’	148	44.6	55.2	2.0	11	7	1.61	27.5
‘Angela’	258	75.1	123.0	2.0	13	8	4.58	30.7
‘Amaya’	250	64.8	96.2	2.0	15	9	3.48	30.4
‘Pardina’	146	44.5	72.1	2.0	12	6	2.77	28.0
‘Lenteja Lura’	170	48.0	70.0	2.0	13	8	2.38	33.1
‘Lenteja Aplo’	127	33.2	36.4	2.0	11	7	1.20	27.0
X	195.8	54.5	77.9	1.9	14	7	3.25	37.8
min	127.2	33.2	36.4	1.5	11	5	4.65	25.5
max	257.7	75.2	123.1	2.0	20	11	1.20	64.1
R (max–min)	130.5	42.0	86.7	0.5	9	6	3.45	38.6
V, %	17.3	21.3	27.8	8.8	14.5	20.2	30.1	25.4

factors and only 45% is determined by varietal characteristics [25]. During the years of study, under the influence of different conditions, the number of pods per plant in the samples of introduced lentil varieties ranged from 33.2 (‘Aplo’, Spain) to 75.2 pieces (‘CDC Cherie’, Canada), the range of variation was 42 pieces, the variability of the indicator is average (coefficient of variation – 21.3%). According to this indicator, 10 samples (38.5%) had an average number of pods per plant – 41.0–50.0 pcs. Seven lentil varieties had a significant number of pods per plant (51.0–64.0), or 27% of their total number. Some samples were characterised by a rather high number of pods per plant – more than 64.0 pieces. Among them are the varieties ‘CDC Imax’ (64.4 pods), ‘CDC Impala’ (65.5 pods per plant), ‘CDC QG-2’ (67.4 pieces), ‘CDC Creenstar’ (67.8 pieces), ‘CDC Cherie’ (75.2 pieces) (Canada), ‘Amaya’ (64.8 pieces), ‘Angela’ (75.1 pieces) (Spain).

Reproductive capacity of the plant, which is determined by the number of seeds on the plant – the main trait that confers a selective advantage to the genotype. The number of seeds per plant is the derivative of the number of pods per plant and the number of seeds in a pod [26]. The average number of seeds per plant over the years of study ranged from 34.6 (‘Aplo’, Spain) to 123.1 (‘CDC Cherie’, Canada), the range of variation was 87.6 pieces, high variability of the indicator was observed (coefficient of variation – 27.8%). The highest number of seeds per plant was produced by the varieties ‘CDC Cherie’ – 123.1 pieces, ‘CDC Impala’ – 93.1, ‘CDC Creenstar’ – 95.1, ‘CDC Imax’ – 92.2, ‘CDC KR-1’ – 92.2, ‘CDC QG-2’ – 94.2, ‘CDC Greenland’ – 91.1, ‘CDC Imigreen’ – 91.5, ‘CDC Impact’ – 92.0 (Canada), ‘Angela’ – 123.0, ‘Amaya’ – 96.2 (Spain). The number of seeds in a pod in the introduced lentil varieties was on average 2 seeds. The range of variation was 0.5 pieces weak coefficient of variation – 8.8%.

The average length of the pod over the years of study was between 11 and 20 mm, with a range of variation of 9 mm, and little variability (coefficient of variation – 14.5%). The longest pod was found in the Canadian variety ‘CDC Creenstar’ (20 mm). The average pod width of the new lentil varieties was 7 mm. Sixteen varieties (61.5%) with a pod width of 4–7 mm were identified. Nine varieties (34.6%) – at the level of 8–10 mm. The widest pod was found in the variety ‘CDC Creenstar’ (Canada) – 11 mm. It should be noted that the colour of the lentil grain is an important quality parameter, as it affects the consumer’s perception and thus the cost of a lentil product [27]. In introduced lentil varieties, the colour of the seed coat was observed: pink, green, yellow-green, grey, brown, grey-red.

The yield of lentils depends on the productivity of the plants, which in turn depends on the interaction of a number of crop structure indicators. One such element is the weight of 1000 seeds, which largely recognises the performance of the variety and is also an important component characterising the food benefits of the variety. The average value of the weight of 1000 seeds in the studied varieties was 37.8 g. The range of variation was 38.6 g. Among the newly introduced lentil studied varieties with a big weight of 1000 seeds – 64.1 g – the variety ‘CDC Creenstar’ (Spain) stood out, according to the average – the Canadian varieties ‘CDC Peridot’ (41.0 g), ‘CDC Impulse’ (45.2 g), ‘CDC Impact’ (55.0 g), ‘CDC Imigreen’ (50.5 g), ‘CDC Impower’ (55.0 g), ‘CDC Dazil’ (40.6 g). The Spanish varieties had a small seed weight ranging from 27.0 to 33.3 g.

The seed weight per plant of the lentil varieties ranged from 4.6 g (‘Angela’) to 1.2 g (‘Lenteja Aplo’, Spain), with an average of 3.2 g. The productivity of the varieties from Canada ranged from 2.0 to 4.5 g. Six varieties were recorded with a seed weight per plant of more than 4.0 g: ‘CDC Cherie’ – 4.4 g, ‘CDC Creenstar’ – 4.2 g, ‘CDC Greenland’ – 4.5 g, ‘CDC Imigreen’ – 4.4 g, ‘CDC QG-2’ – 4.1 g, ‘CDC Impulse’ – 4.0 g (Canada), ‘CDC Imigreen’ – 4.4 g, ‘CDC QG-2’ – 4.1 g, ‘CDC Impulse’ – 4.0 g (Canada), ‘Angela’ – 4.6 g (Spain), which have relatively high plant productivity rates due to the larger number of pods per plant.

Yield depends on many factors, determined both by the genetic characteristics of the plants – resistance to diseases, pests and stresses, root absorption capacity, ratio of grain to by-products, etc. – and by the environmental conditions – sufficient light, moisture and nutrients in the soil. Seed yield per unit area consists of the productivity of a plant and its total number. Genotype and environmental conditions are the dominant factors influencing the amount of crop harvested [28]. On average over three years of research, the most productive varieties were ‘CDC Creenstar’ 250 g/m^2, CDC ‘Cherie’ 248 g/m^2 (Canada), ‘Angela’ 258 g/m^2 and ‘Amaya’ 250 g/m^2 (Spain), i.e. 28.0, 26.0, 35.0, 28.0 g/m^2 more than the standard. The ‘CDC Greenland’ varieties were characterised by a relatively high average yield at the standard level, ‘CDC KR-1’, ‘CDC Asterix’ – 210–228 g/m^2 (Table 3).

Varieties combining several valuable traits deserve special attention. In particular, as a result of the study of the newly introduced lentil material, promising samples have been selected which can be used as source material for breeding according to the following economic and valuable characteristics:

– *productivity* (> 230 g/m^2) (in the standard variety 'Linza' – 222 g/m^2), *the number of pods per plant* (> 60.0 pcs.), *the number of seeds per plant* (> 90.0 pcs) and *the productivity of the plant* (> 4.0 g) – 'CDC Cherie', 'CDC QG-2', 'CDC Imigreen', 'CDC Greenland' (Canada), 'Angela' (Spain);

– *productivity* (> 230 g/m^2) (in the standard variety 'Linza' – 222 g/m^2), *number of pods per plant* (> 60.0 pcs), *number of seeds per plant* (> 90.0 pcs) – 'CDC KR-1' (Canada), 'Amaya' (Spain);

– *productivity* (> 230 g/m^2) (in the standard variety 'Linza' – 222 g/m^2), *number of pods per plant* (> 60.0 pcs.), *number of seeds per plant* (> 90.0 pcs), *plant productivity* (> 4.0 g) and *weight of 1000 seeds* (> 50.0 g) – 'CDC Creenstar', 'CDC Impact' (Canada);

– *number of pods per plant* (> 60.0) and *number of seeds per plant* (> 90.0) – 'CDC Imax', 'CDC Impala' (Canada).

Conclusions

In order to determine the possibility of realising the genetic potential of introduced samples, it is important to carry out research over a number of years to record the behavior of the samples under different agronomic conditions. Under the conditions of the southern part of the Ukrainian Forest Steppe, the investigated lentil samples produced grain yields ranging from 127 to 258 g/m^2. Analysis of the average yield over the years of research shows that the most productive varieties include 'CDC Creenstar', 'CDC Cherie' (Canada), 'Angela', 'Amaya' (Spain). On average during the years of research, the following lentil varieties showed the highest productivity – 'CDC Cherie' (4.4 g), CDC Creenstar' (4.2 g), 'CDC Greenland' (4.5 g), 'CDC Imigreen' (4.4 g), 'CDC QG-2' (4.1 g), 'CDC Impulse' (4.0 g) (Canada), 'Angela' (4.6 g) (Spain). Plant productivity was high, both in terms of increased seed number and 1000 seed weight. The varieties 'CDC Creenstar', 'CDC Greenland', 'CDC Impulse', 'CDC Impact' (Canada), 'Angela' (Spain) were selected on the basis of the set of characteristics. The above varieties can be recommended as sources of valuable characteristics for practical use in breeding, and they are also suitable for cultivation in the Southern Forest Steppe zone, provided that they are included in the State Register of Plant Varieties Suitable for Distribution in Ukraine.

References

1. Petkevych, Z. Z., & Melnychenko, A. V. (2016). Chickpeas, lentils – promising legumes for cultivation in southern Ukrainian. *Irrigated Agriculture*, *65*, 104–107. [In Ukrainian]
2. Jawad, M., Malik, S. R., Sarwar, M. A., Asadullah, M., Hussain, I., & Khalid, R. (2018). Genetic analysis of lentil (*Lens culinaris*) exotic germplasm to identify genotypes suitable for mechanical harvesting. *Pakistan Journal of Agricultural Research*, *32*(1), 152–158. doi: 10.17582/journal.pjar/2019/32.1.152.158
3. Didur, I. M., & Korshevnyuk, S. P. (2021). Formation of a symbiotic apparatus of lentil depending on inoculation and processing of seeds with microelements. *Agriculture and Forestry*, *23*, 52–66. doi: 10.37128/2707-5826-2021-4-5 [In Ukrainian]
4. FAOSTAT. (2023). Retrieved from http://www.fao.org/faostat/en/
5. Choukri, H., Hejjaoui, K., El-Baouchi, A., El Haddad, N., Smouni, A., Maalouf F., … Kumar, S. (2020). Heat and Drought Stress Impact on Phenology, Grain Yield, and Nutritional Quality of Lentil (*Lens culinaris* Medikus). *Frontiers in Nutrition*, *23*, Article 596307. doi: 10.3389/fnut.2020.596307
6. Sichkar, V. I., Orekhivskyi, V. D., Kryvenko, A. I., Mamatov, N. A., & Solomonov, R. V. (2018). Peculiarities of biology of lentil development. *The Bulletin of Kharkiv National Agrarian University. Crop Production, Breeding and Seed Production, Horticulture*, *1*, 190–203. [In Ukrainian]
7. Klisha, A. I., Kulinich, O. O., & Korzh, Z. V. (2016). Correlation between yield traits of lentil and its breeding. *Grain Crops*, *10*, 20–36. [In Ukrainian]
8. Kulinich, O. O., Kandaurova, K. F., & Kobos, I. O. (2021). Study of lentil varieties from Canada and Turkey in the Northern Steppe of Ukraine. *Plant Genetic Resources*, *29*, 20–28. doi: 10.36814/pgr.2021.29.02 [In Ukrainian]
9. Prajapati, A., Singh, R. P., Kumar, B., & Kewat, R. N. (2020). Physical and biochemical studies of lentil (*Lens culinaris* Medik.) varieties. *International Journal of Current Microbiology and Applied Sciences*, *11*, 20–27. Retrieved from https://www.ijcmas.com/special/11/Atul%20Prajapati,%20et%20al.pdf
10. Kumar, S. K., Barpete, S., Kumar, J., Gupta, P., & Sarker, A. (2013). Global Lentil Production: Constraints and Strategies. *SATSA Mukhapatra – Annual Technical Issue*, *17*, 1–13. Retrieved from https://hdl.handle.net/20.500.11766/7217
11. Plaza, J., Morales-Corts, M. R., Pйrez-Sбnchez, R., Revilla, I., & Vivar-Quintana, A. M. (2021). Morphometric and nutritional characterization of the main spanish lentil cultivars. *Agriculture*, *11*(8), 1–14. doi: 10.3390/agriculture11080741
12. Sichkar, V., Kryvenko, A., & Solomonov, R. (2020). Lantil in world and Ukraine: current state and prospects. *Journal of Native and Alien Plant Studies*, *16*, 178–193. doi: 10.37555/2707-3114.16.2020.219830
13. Vus, N. A., Bezuglaya, O. N., Kobyzeva, L. N., Bozhko, T. N., Vasilenko, A. A., & Shelyakina, T. A. (2020). A feature collection of lentil (*Lens culinaris* Medik.) by nutritious value of seeds. *Plant Breeding and Seed Production*, *117*, 25–36. doi: 10.30835/2413-7510.2020.206962 [In Ukrainian]
14. Kaale, L. D., Siddiq, M., & Hooper, S. (2022). Lentil (*Lens culinaris* Medik.) as nutrient-rich and versatile food legume: A review. *Legume Science*, *5*(2), Article e169. doi: org/10.1002/leg3.169
15. Kobyzeva, L. N., Bezugla, O. N., & Bozhko, T. N. (2008). Lentil national collection of Ukraine analyzed by its sample's adaptability to mechanical harvesting. *Plant Genetic Resources*, *5*, 132–136. [In Ukrainian]
16. Barrios, A., Aparicio, T., Rodríguez, M. J., Pérez de la Vega, M., & Caminero, C. (2016). Winter sowing of adapted lines as a potential yield increase strategy in lentil (*Lens culinaris* Medik.). *Spanish Journal of Agricultural Research*, *14*(2), Article e0702. doi: 10.5424/sjar/2016142-8092

17. Matny, O. N. (2015). Lentil (*Lens culinaris* Medikus) current status and future prospect of production in Ethiopia. *Advances in Plants and Agriculture Research*, *2*(3), 45–53. doi: 10.15406/apar.2015.02.00040
18. Klisha, A. I., Kulinych, O. O., & Korzh, Z. V. (2017). The relationship between productivity traits in lentil and their effect on yield. *Grain Crops*, *1*, 16–20. [In Ukrainian]
19. Kobyzeva, L. N, Bezugla, O. M, Sylenko, S. I, Kolotylov, V. V, Sokol, T. V., Dokukina, K. I, … Vus, N. O. (2016). *Metodychni rekomendatsii z vyvchennia henetychnykh resursiv zernobobovykh kultur* [Methodical recommendations for studying the genetic resources of grain legumes]. Kharkiv: N. p. [In Ukrainian]
20. Tkachyk, S. O. (Ed.). (2016). *Metodyka provedennia ekspertyzy sortiv roslyn hrupy zernobobovykh ta krupianykh na vidminnist, odnoridnist i stabilnist* [Methods of examination of plant varieties of leguminous plants and cereals for difference, uniformity and stability]. (2[rd] ed., rev). Vinnytsia: FOP Korzun D. Ya. [In Ukrainian]
21. Kyrychenko, V. V., Kobyzieva, L. N., Petrenkova, V. P., Riabchun, V. K., Bezuhla, O. M., Markova, T. Yu., … Riabukha, S. S. (2009). *Identyfikatsiia oznak zernobobovykh kultur (beans, chickpeas, lentils)* [Identification of characters of leguminous crops (peas, soybean)]. V. V. Kyrychenko (Ed.). Kharkiv: Kharkiv. [In Ukrainian]
22. Sichkar, V. I., Orekhivskyi, V. D., Kryvenko, A. I., Mamatov, N. A., & Solomonov, R. V. (2018). Peculiarities of biology of lentil development. *The Bulletin of Kharkiv National Agrarian University. Crop Production, Breeding and Seed Production, Horticulture*, *1*, 190–203. [In Ukrainian]
23. Vitko, G. I. (2017). Research into initial material of vegetable peas according to a complex of economically valuable traits. *Bulletin of the Belarussian State Agricultural Academy*, *3*, 57–62.
24. Sorokina, I. Yu., & Kumacheva, V. D. (2022). A study of lentil samples for the purposes of creating new varieties in the south of Russia. *International Research Journal*, *1*, 140–142. doi: 10.23670/IRJ.2022.115.1.028
25. Vozhehova, R. A., Borovyk, V. O., Klubuk, V. V., & Rubtsov, D. K. (2018). Selection value of sources of valuable attributes of introduced soybean samples (*Glycine max* L.) for new varieties creation under irrigated conditions of the South of Ukraine. *Plant Varieties. Studying and Protection*, *14*(2), 176–182. doi: 10.21498/2518-1017.14.2.2018.124765. [In Ukrainian]
26. Semenova, E. V., & Sobolev, D. V. (2009). Productivity of pea (*Pisum sativum* L.) accessions from the VIR collection in the Leningrad Region. *Proceedings on Applied Botany, Genetics and Breeding*, *166*, 242–249.
27. Shahin, M. A., & Symons, S. J. (2001). A machine vision system for grading lentils. *Canadian Biosystems Engineering*, *43*, 7.7–7.14.
28. Karadavut, U. (2009). Path analysis for yield and yield components in lentil (*Lens culinaris* Medik.). *Turkish Journal of Field Crops*, *14*(2), 97–104. Retrieved from https://dergipark.org.tr/en/pub/tjfc/issue/17129/179177

Використана література

1. Петкевич З. З., Мельніченко Г. В. Нут, сочевиця – перспективні зернобобові культури для вирощування на Півдні України. *Зрошуване землеробство.* 2016. Вип. 65. С. 104–107.
2. Jawad M., Malik S. R., Sarwar M. A. et al. Genetic analysis of lentil (*Lens culinaris*) exotic germplasm to identify genotypes suitable for mechanical harvesting. *Pakistan Journal of Agricultural Research*. 2018. Vol. 32, Iss. 1. P. 152–158. doi: 10.17582/journal.pjar/2019/32.1.152.158
3. Дідур І. М., Коршевнюк С. П. Формування симбіотичного апарату сочевиці залежно від інокуляції та обробки насіння мікроелементами. *Сільське господарство та лісівництво.* 2021. № 23. С. 52–66. doi: 10.37128/2707-5826-2021-4-5
4. FAOSTAT. URL: http://www.fao.org/faostat/en/
5. Choukri H., Hejjaoui K., El-Baouchi A. et al. Heat and drought stress impact on phenology, grain yield, and nutritional quality of lentil (*Lens culinaris* Medikus). *Frontiers in Nutrition.* Vol. 7. Article 596307. doi: 10.3389/fnut.2020.596307
6. Січкар В. І., Орехівський В. Д., Кривенко А. І. та ін. Особливості біології розвитку сочевиці. *Вісник Харківського національного аграрного університету ім. В. В. Докучаєва. Серія : Рослинництво, селекція і насінництво, плодоовочівництво і зберігання.* 2018. Вип. 1. С. 190–203.
7. Клиша А. І., Кулініч О. О., Корж З. В. Показники продуктивності сочевиці та її селекція. *Зернові культури*. 2016. № 10. С. 20–36.
8. Кулініч О. О., Кандаурова К. Ф., Кобос І. О. Зразки сочевиці Канади і Туреччини в умовах Північного Степу України. *Генетичні ресурси рослин*. 2021. № 29. С. 20–28. doi: 10.36814/pgr.2021.29.02
9. Prajapati A., Singh R. P., Kumar B., Kewat R. N. Physical and biochemical studies of lentil (*Lens culinaris* Medik.) varieties. *International Journal of Current Microbiology and Applied Sciences*. 2020. Spec. Iss. 11. P. 20–27. URL: https://www.ijcmas.com/special/11/Atul%20Prajapati,%20et%20al.pdf
10. Kumar S. K., Barpete S., Kumar J. et al. Global lentil production: constraints and strategies. *SATSA Mukhapatra – Annual Technical*. 2013. Iss. 17. P. 1–13. URL: https://hdl.handle.net/20.500.11766/7217
11. Plaza J., Morales-Corts M. R., Pérez-Sénchez R. et al. Morphometric and nutritional haracterization of the main spanish lentil cultivars. *Agriculture*. 2021. Vol. 11, Iss. 8. P. 1–14. doi: 10.3390/agriculture11080741
12. Січкар В., Кривенко А., Соломонов Р. Сочевиця у світі та Україні: сучасний стан і перспективи. *Journal of Native and Alien Plant Studies*. 2020. № 16. С. 178–193. doi: 10.37555/2707-3114.16.2020.219830
13. Vus N. A., Bezuglaya O. N., Kobyzeva L. N. et al. A feature collection of lentil (*Lens culinaris* Medik.) by nutritious value of seeds. *Селекція і насінництво*. 2020. Вип. 117. С. 25–36. doi: 10.30835/2413-7510.2020.206962
14. Kaale L. D., Siddiq M., Hooper S. Lentil (*Lens culinaris* Medik) as nutrient-rich and versatile food legume: A review. *Legume Science*. 2022. Vol. 5, Iss. 2. Article e169. doi: 10.1002/leg3.169
15. Кобизєва Л. Н., Безугла О. М., Божко Т. М. Аналіз національної колекції сочевиці України за придатністю зразків до механізованого збирання урожаю. *Генетичні ресурси рослин*. 2008. № 5. С. 132–136.
16. Barrios A., Aparicio T., Rodríguez M. J. et al. Winter sowing of adapted lines as a potential yield increase strategy in lentil (*Lens culinaris* Medik.). *Spanish Journal of Agricultural Research*. 2016. Vol. 14, Iss. 2. Article e0702. doi: 10.5424/sjar/2016142-8092
17. Matny O. N. Lentil (*Lens culinaris* Medikus) current status and future prospect of production in Ethiopia. *Advances in Plants and Agriculture Research*. 2015. Vol. 2, Iss. 2. P. 45–53. doi: 10.15406/apar.2015.02.00040
18. Клиша А. І. Кулініч О. О., Корж З. В. Взаємозв'язок ознак продуктивності у сочевиці. *Зернові культури*. 2017. Т. 1, № 1. С. 16–20.
19. Кобизєва Л. Н., Безугла О. М., Силенко С. І. та ін. Методичні рекомендації з вивчення генетичних ресурсів зернобобових культур. Харків, 2016. 84 с.
20. Методика проведення експертизи сортів рослин групи зернобобових та круп'яних на відмінність, однорідність і стабільність / за ред. С. О. Ткачик. 2-ге вид., випр. і доп. Вінниця : ФОП Корзун Д. Ю., 2016. 178 с.
21. Кириченко В. В., Кобизєва Л. Н., Петренкова В. П. та ін. Ідентифікація ознак зернобобових культур (квасоля, нут, сочевиця) / за ред. В. В. Кириченка. Харків : Харків, 2009. 118 с.
22. Січкар В. І., Орехівський В. Д., Кривенко А. І. та ін. Особливості біології розвитку сочевиці. *Вісник ХНАУ. Серія : Рослинництво, селекція і насінництво, плодоовочівництво і зберігання*. 2018. № 1. С. 190–203.
23. Витко Г. И. Изучение исходного материала овощного гороха по комплексу хозяйственно полезных признаков. *Вестник Белорусской государственной сельскохозяйственной академии*. 2017. № 3. С. 57–62.

24. Сорокина И. Ю., Кумачева В. Д. Изучение коллекционных образцов чечевицы для создания новых сортов в условиях юга России. *Международный научно-исследовательский журнал*. 2022. № 1, Ч. 1. С. 140–142. doi: 10.23670/IRJ.2022.115.1.028
25. Вожегова Р. А., Боровик В. О., Клубук В. В., Рубцов Д. К. Селекційне значення джерел цінних ознак інтродукованих зразків сої (*Glycine max* L.) для створення нових сортів в умовах зрошення Півдня України. *Plant Varieties Studying and Protection*. 2018. Т. 14, № 2. С. 176–182. doi: 10.21498/2518-1017.14.2.2018.124765
26. Семенова Е. В., Соболев Д. В. Продуктивность образцов гороха (*Pisum sativum* L.) из коллекции ВИР в условиях Ленинградской области. *Труды по прикладной ботанике, генетике и селекции*. 2009. Т. 166. С. 242–249.
27. Shahin M. A., Symons S. J. A machine vision system for grading lentils. *Canadian Biosystems Engineering*. 2001. Vol. 43. P. 7.7–7.14.
28. Karadavut U. Path analysis for yield and yield components in lentil (*Lens culinaris* Medik.). *Turkish Journal of Field Crops*. 2009. Vol. 14, Iss. 2. P. 97–104. URL: https://dergipark.org.tr/en/pub/tjfc/issue/17129/179177

УДК 635.658:631.527

Холод С. М.[1]*, Кузьмишина Н. В.[2], Тригуб О. В.[1], Кір'ян В. М.[1] Характеристика інтродукованих сортозразків сочевиці (*Lens culinaris* Medik.) у зоні Південного Лісостепу України. *Plant Varieties Studying and Protection*. 2023. Т. 19, № 2. С. 72–80. https://doi.org/10.21498/2518-1017.19.2.2023.282548

*[1]Устимівська дослідна станція рослинництва Інституту рослинництва ім. В. Я. Юр'єва НААН України, вул. Академіка Вавилова, 15, с. Устимівка, Глобинський р-н, Полтавська обл., 39074, Україна, *e-mail: svitlanakholod77@ukr.net*

[2]Інститут рослинництва ім. В. Я. Юр'єва НААН. Національний центр генетичних ресурсів рослин України, пр-т Героїв Харкова, 142, м. Харків, 61060, Україна, e-mail: ncpgru@gmail.com

Мета. Інтродуковані сорти сочевиці (*Lens culinaris* Medik.), країнами походження яких є Канада та Іспанія, оцінити за комплексом показників продуктивності й адаптивності, продемонстрованих ними в умовах південної частини Лісостепу України. **Методи.** Впродовж 2019–2021 рр. на Устимівській дослідній станції рослинництва Інституту рослинництва ім. В. Я. Юр'єва НААН (Полтавська обл., 49°18′21″ N, 33°13′56″ E) досліджували 26 нових зразків сочевиці, що походять з Іспанії та Канади. У фазі достигання бобів і насіння (BBCH 86–90) в польових та лабораторних умовах визначали показники врожайності, продуктивності, маси 1000 насінин, скоростиглості, висоти рослин та прикріплення нижніх бобів над рівнем ґрунту, кількості бобів і насіння на рослині, кількості насіння в бобі, параметри бобу. **Результати.** Виявлено значне варіювання врожайності нових зразків сочевиці – від 127 до 258 г/м^2. Найбільшими її показниками відзначилися сорти 'CDC Creenstar' і 'CDC Cherie' з Канади та 'Angela' й 'Amaya' з Іспанії. Найпродуктивнішими під час досліджень виявилися 'CDC Cherie' (4,4 г), 'CDC Creenstar' (4,2 г), 'CDC Greenland' (4,5 г), 'CDC Imigreen' (4,4 г), 'CDC QG-2' (4,1 г), 'CDC Impulse' (4,0 г) – Канада; 'Angela' (4,6 г) – Іспанія, що зумовлено підвищеними кількістю насінин і масою 1000 зерен. Найбільшу кількість бобів на рослині зафіксовано в сортів 'CDC Imax' (64,4 шт.), 'CDC Impala' (65,5 шт.), 'CDC QG-2' (67,4 шт.), 'CDC Creenstar' (67,8 шт.) і 'CDC Cherie' (75,2 шт.) – Канада; 'Amaya' (64,8 шт.) та 'Angela' (75,1 шт.) – Іспанія. Майже всі досліджені зразки виявилися середньостиглими (81–85 діб) та оптимальними для зони Південного Лісостепу України. Найскоростиглішими (76 діб) були канадські сорти 'CDC QG-2', 'CDC SB-2', 'CDC Impulse', 'CDC Imvincible' та 'CDC Impact'. На особливу увагу заслуговують 'CDC Creenstar', 'CDC Greenland', 'CDC Impulse' та 'CDC Impact' з Канади, а також 'Angela' з Іспанії, які поєднали в собі кілька цінних ознак. **Висновки.** Вищезазначені сорти є придатними для вирощування в зоні Південного Лісостепу України та можуть бути рекомендовані як джерела цінних ознак для практичного використання в селекції.

Ключові слова: *сочевиця; сортозразки; цінні господарські ознаки; продуктивність; вегетаційний період; висота рослин; маса 1000 насінин.*

Надійшла / Received 02.06.2023
Погоджено до друку / Accepted 26.06.2023